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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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Volume 3 **SEPTEMBER, 1924** **Number 9**

TABLE OF CONTENTS

Society and Related Activities **Page**

Fall Meeting 3
Membership Directory 4
Welding Minded 4
National Research Council 5
Rail Joint Committee 6
Membership Drive 6
Section Activities 7
Employment Service Bulletin 9

Technical Papers, Items and Reports

Spot Welding Aluminum and Duralumin 10
Welded Piping in Buildings 11
Welding of Punch Press 15
Arc Welding High Pressure Steam Lines 16
Welding High Speed Steel 17
Welding and Cutting in the Plumbing and Heating Industry 18
Spot Welding 23
Resistance Welding Data 26
Current Welding Literature 31

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 3 September, 1924 Number 9

FALL MEETING TO BE HELD IN CLEVELAND

The Fall meeting of the Society will this year be held in Cleveland, on Oct. 30 and 31. Strenuous efforts are being made by the Meetings and Papers Committee to make this meeting one of the outstanding accomplishments of the American Welding Society. Members will find that the program is both interesting and profitable.

Thursday morning will be devoted to registration of the members and an address of welcome by the Chairman of the Cleveland Section and the President of the American Welding Society. An opportunity will also be afforded for members to get together and renew acquaintances and friendships. As one of our prominent engineers has stated, a chance to talk things over with the other fellow and find out what he is working upon, his accomplishments and difficulties, is in itself worth the trip to the fall meeting.

An inspection trip will be arranged by the Cleveland Committee on Thursday afternoon, although full details have not yet been reported to headquarters. Efforts are being made to arrange a boat trip to the National Tube Company's plant at Lorain. If such arrangements are concluded satisfactorily, and the weather permits, lunch will be served on the boat on the way out and dinner on the return trip.

The technical session will be held Friday morning and will be devoted to a number of papers on the general subject of applications of welding in the construction of bridges, buildings, etc. In order to bring about this extension, a great deal of information is needed which will require elaborate and costly investigations. Not only will it be necessary to summarize in usable form results attained in service where welding has already been used in the construction of buildings and bridges, but it will also be necessary to furnish engineers, designers and draftsmen with accurate data as to costs, methods to be used and engineering data as to types of joints, strength to be expected, factors of safety, etc. Moreover, it will be necessary to convince legislators that welding is safe and adequate for the purpose intended. All of this requires data that does not now exist and it is the intention of the American Bureau of Welding to secure this information at a minimum cost to the industry and in such a way that it will be recognized as authoritative. The problem of the Bureau does not even end here, as it will then be necessary to show engineers and contractors how to go about the adjusting of their fabricating and shop methods so that the work can be satisfactorily and economically performed.

In order to bring to the attention of our members the importance of this work and its possibilities, the Meetings and Papers Committee have decided to devote the technical session of the fall meeting to this general subject.

It is anticipated that a number of prominent guests, including some of the leading structural engineers of the country, will be present at this meeting, and it is hoped that a luncheon can be arranged in honor of these guests to follow the meeting.

No doubt many members have often wondered what transpires at a meeting of the Board of Directors of our Society, what subjects are taken up, how they are discussed. In order to give everyone an insight into such meetings, the Board of Directors have decided to hold a meeting on Friday afternoon which will be open to all the members of the Society. In particular it is hoped that at this meeting the Board of Directors with the assistance of the members of the Society will be able to lay out plans for activities which will increase our membership and bring about accom-

plishments which will make the American Welding Society one of the foremost technical organizations in the world.

Later in the afternoon the Meetings and Papers Committee will hold a meeting with the chairmen and secretaries of the various sections in order to lay plans for bringing about better monthly section meetings.

The demonstrations and exhibitions scheduled for Friday evening are in themselves worth the trip to Cleveland. No expense and trouble has been spared by the Society and cooperating companies. There will be a motion picture presented by the Air Reduction Sales Company, "Oxygen—The Wonder Worker." This film, which consists of four reels, shows how liquid air is made; why it is possible to separate the gases of the atmosphere; how oxygen is extracted from the air; how the high temperature (6300 deg. Fahr.) of the oxyacetylene flame is produced; how carbide is made and acetylene gas generated; how iron, steel, copper, brass, aluminum and other metals are welded; how steel and cast iron are cut; how the oxyacetylene torch is adapted to mechanical cutting and welding; and how welding and cutting operations of great economical value are performed in some of the country's important industrial plants and railroad shops. We have often wondered what happens in metallic arc welding. Through the courtesy of the General Electric Company and the assistance of their Projector the actual process of metallic arc welding will be shown on the screen where everyone can see it. What are the possibilities of liquid oxygen? You will see mercury frozen so hard that it can be used as a hammer to drive nails or a rubber ball so stiff that it can be broken like glass with a hammer. These and other stunts will be included in the demonstration arranged through the courtesy of the Air Reduction Sales Company. Some of our members have also been fortunate enough to actually see some thermit welding and how it is accomplished, starting with the preparation of the molds to the ignition of the thermit mixture. An actual demonstration will be shown during the meeting.

MEMBERSHIP DIRECTORY

Every member of the Society received a copy of the first membership directory as the August issue of the Journal. It is planned to revise this directory every year and continue its publication as the August number. In this way there will be available a yearly permanent record of those identified with the welding industry.

Great pains were taken to make this directory as accurate as possible with the information at hand. One of the functions which the Membership Committee hope that this directory will accomplish is the securing of new members. It is very easy to check whether one's friends are members of the Society and, if not, the advantages of joining can be brought to their attention. The Membership Committee requests that every member notify the Secretary of the Society of the names and addresses of prospective members. An extra copy of the Membership Directory will at once be sent to these prospects together with an application blank. Through the cooperation of every member of the Society it is hoped that the membership will be increased to double the present number within a few months.

"WELDING MINDED"

There is reproduced below an editorial which appeared in the July 12, 1924, issue of the *Electrical World.* What is said of electric welding applies of course with equal force to all processes of welding.

Are Electrical Men "Welding-Minded"?

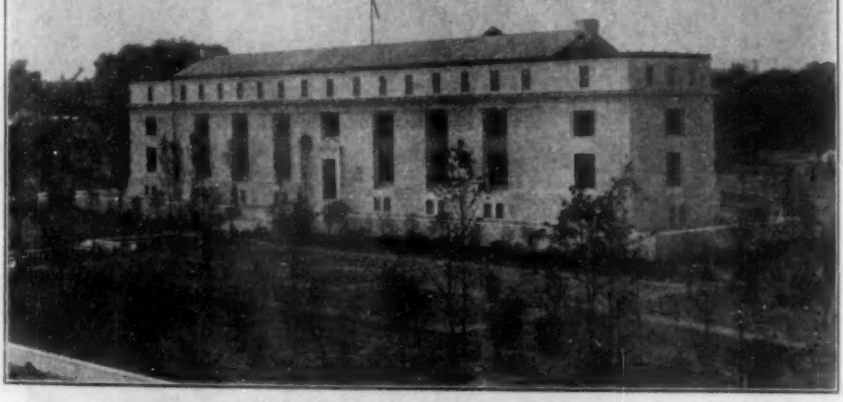
A certain manufacturer of electrical apparatus has made an extensive development of electric welding equipment. Starting with an enthusiastic confidence in the value of electric welding as a factory process, he has produced a successful welding unit and built himself a strong place in the growing market. In the course of the designing and perfecting of this equipment his organization has naturally become more and more keenly interested in possibilities for the application of welding in the construction and assembling of its own machinery, and has discovered and devised a surprising variety of ingenious uses for welded steel parts where bolted castings had been formerly employed. There has been great saving in weight of metal, labor and resultant costs. Resort to welding in its factory has steadily increased. In fact, the works manager frankly states that, were either necessary, he could more easily dispense with electric power than with electric welding.

The extent to which the use of weld-

ing has progressed and expanded in this factory—and in many others—clearly indicates how great a success it has become and the tremendous future promised for this great industrial utilization of electrical energy. The reason why this interested manufacturer of welding equipment has been able to develop the use of welding so far is that he himself is "welding-minded." He is "sold" on the possibilities of this process. He is approaching problems with the hope that here may be another place where welding will help him simplify and save, and so he finds new opportunities to weld. The trouble is that the average manufacturer is naturally prejudiced in favor of his established method and against an innovation. But the central-station power salesman can and should be "welding-minded" and, recognizing the importance of such a service to the manufacturer, set himself to find out how he can profitably serve the load. It is important that the entire electrical industry should be "welding-minded." For electric welding will revolutionize the methods of many factories when electrical men begin enthusiastically to search for and devise new ways to use this very effective industrial application of central station power.

NATIONAL RESEARCH COUNCIL

From time to time there has been published in the Journal editorials and papers explaining the affiliation of our Research Department (American Bureau of Welding) with the National Research Council.



New National Research Council Building

The Research Council was organized originally to coordinate scientific attack in solving war problems. Its success led the President of the United States to establish it permanently. Although all governmental departments have been instructed by the President to cooperate with the Council, it is not a governmental institution. Administrative expenses are paid from an income of an endowment of $5,000,000. During the past year there has been erected in Washington near the Lincoln Memorial a building to house the National Research Council and the National Academy of Sciences. This building cost approximately $1,500,000 and is one of the most important office buildings in the city. The Council has 13 divisions, one of which is the Division of Engineering and Industrial Research. The American Welding Society is concerned particularly with this division. The Division of Engineering is cooperating with each of the national engineering societies in coordinating and promoting research in the various fields of engineering. Welding is one of the important fields of investigation and the Research Council has done its utmost to encourage the American Welding Society in its welding investigations.

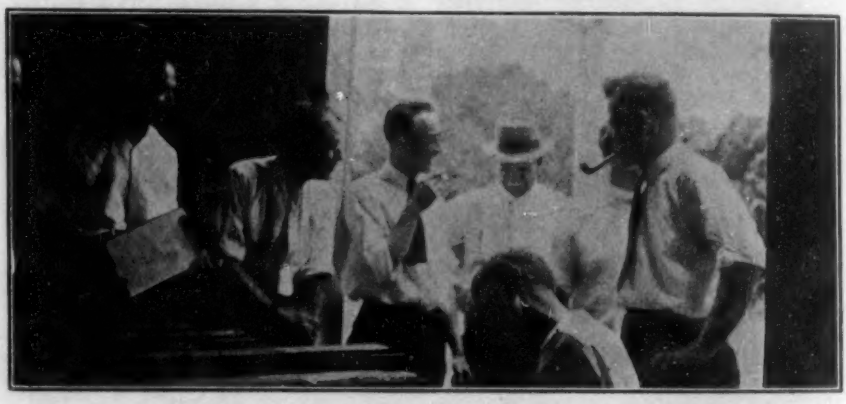
One of the tangible ways in which it is helping is in allowing the Secretary of the Division of Engineering to devote a very considerable portion of his time to act as the Secretary of the Research Department of the Society (American Bureau of Welding).

As many of our members know, the American Bureau of Welding is planning to embark upon its largest investigation so far. This investigation will have for its purpose the extension of the use of welding in the structural field, such as bridges, buildings, cranes, etc. In order to successfully conduct this research work there will be required talent and engineering experience outside of the field of welding. Through its contacts the Council is particularly fitted to secure the necessary cooperation of individuals and companies. Moreover, a sum of approximately $200,000 will have to be raised. It is hoped that the Council will render material assistance in raising these funds.

WELDED RAIL JOINT EXPERTS AT WORK

Below is shown a photograph of some members of the Welded Rail Joint Committee at work at the Bureau of Standards, Washington. They are making a detailed examination of the joints broken by the tensile, drop and bend tests made at the University of Illinois, Bureau of Standards and Purdue University. Their object in making this examination is to discover, if possible, causes of failure and other information not revealed by data obtained from the testing machines. These facts will be used in laying out a program of further investigation seeking to improve each type of joint.

The occasion of the above examination was a meeting of the Executive Committee at the Bureau of Standards during the latter part of July in which a program of future activities of the committee was laid out. A machine has been designed and built by the committee for giving test joints repeated blows of a magnitude comparable to that given by a trolley car in passing over a defective joint. This machine is now in operation pounding away continuously.



Rail Joint Committee at Work
Standing Left to Right—Ryder, Whittemore, Petrik, Kleinshmidt, Begtrup. Seated—Miller

The final or even a progress report of a Research Committee does not always bring out the enormous amount of work, time and effort which must be given freely by members and friends of the Society.

MEMBERSHIP DRIVE

It has been some time since the Membership Committee has called upon every member of the Society to render assistance in securing new members. Just before the Membership Directory was published a few of our most loyal supporters, including section officers, were called upon to get new members.

Now that the Directory has been printed, it is possible for each member to check up whether his friends are members of the Society and to

personally solicit such membership in those cases where they are not. In the past when such a call was made a limited number of our members responded. It was practically impossible to keep a record in the office of those who fulfilled their responsibility in this matter except perhaps in the case of a few outstanding examples.

Not only will records be kept of those who secure members but each month the Journal will publish the list of new members together with the proposer and in this way publicly acknowledge the work of the Society members.

The Membership Committee is anxious to cooperate with you in this campaign and if you are unable yourself to convince a prospective member of the advantages of joining the Society, the central office will at once join you in such endeavor and if successful this new member will be placed to your credit.

An additional membership directory and application blank will be sent you upon request. C. A. McCUNE,
Chairman, Membership Committee.

SECTION ACTIVITIES

Most of the local sections of the American Welding Society are planning to begin their year's activities with a September meeting. Several of the larger sections have already arranged programs for the entire year. These are reproduced below.

Philadelphia:

Sept. 15, 1924—Motion pictures and paper, by H. H. Griffith of the Oxweld Acetylene Co., entitled "New Applications of Welding and Cutting by Oxy-Acetylene Process."

Oct. 20, 1924—Motion pictures and paper presenting, "The Possibilities of Thermit, Past, Present and Future," by J. H. Deppeler, Ch. Engr. of Metal and Thermit Corp'n.

Nov. 17, 1924—Slides and paper presenting "Progress of Safety in Welding," by Col. Royal Mattice, president, Mattice Engineering Company.

Dec. 19, 1924—Philadelphia Night. "The Effect of Annealing Upon the Crystal Structure of Cold Worked Steel," presented by Dr. George L. Kelly, Metallurgist, Ed. G. Budd Mfg. Co.

Jan. 19, 1925—Illustrated paper "Some Applications of Butt and Spot Welding in Modern Industry," presented by Mr. Woofter, electrical engineer, Thomson Electric Welding Company.

Feb. 16, 1925—Illustrated paper "Molten Metal in an Acetylene Atmosphere," presented by Prof. A. S. Kinsey, of Stevens Institute of Technology.

March 16, 1925—Illustrated paper, by the Linde Air Products Company. Speaker and subject to be announced later.

April 20, 1925—Illustrated paper, "Welded Pressure Vessels," presented by S. W. Miller, past president, American Welding Society.

Chicago:

Sept. 5, 1924—Motion pictures of "Six Inch Bronze Welded Cast Iron Pipe at Bay Shore, Long Island," Address by J. C. Headley.

Oct. 3, 1924—Paper, "Scrapping Steel Freight Cars With the Electric Arc," by A. M. Candy, Gen. Eng. Dept., Westinghouse Electric and Mfg. Company, East Pittsburgh, Pa.

Nov. 7, 1924—Paper upon "Acetylene," by David Ahldin, associated with M. Keith Dunham, Chicago, Ill.

Dec. 5, 1924—Paper entitled "Why the Flux Coated Electrode," by C. J. Holslag, of the Electric Arc Cutting and Welding Company, Newark, N. J.

Jan. 2, 1925—Paper, by G. O. Carter, of the Linde Air Products Company, New York. Subject to be announced later.

Feb. 6, 1925—Paper entitled "Welding as Accomplished at the Wabash Railroad Shops at Decatur, Ill.," by J. A. Heaton, supt. of welding, Wabash Railroad Company, Decatur.

March 6, 1925—Paper entitled "Autogenous Welding as Practised by the Atchison, Topeka and Santa Fe Rway. Co.," by E. E. Chapman, of the A. T. and S. F. R. R., prepared in collaboration with H. H. Service, gas welding engineer of the Santa Fe System, illustrated by lantern slides.

April 3, 1925—Moving Pictures of "Applications of Welding and Cutting," will be exhibited by C. E.

Zeisel of the Oxweld Acetylene Company, Chicago.

May 1, 1925—Paper, by G. A. Ellinger, Metallurgists' office, Santa Fe R. R. office, Topeka, Kan. Subject of this paper will be announced later and will include lantern slides.

Western New York:

Sept. 17, 1924, Rochester, N. Y.—"Arc Welding and Cutting by the A.C. Process," C. J. Holslag, Electric Arc Cutting and Welding Co.

Oct. 15, 1924, Buffalo, N. Y.—"Thermit," by Metal and Thermit Corp'n.

Nov. 12, 1924, Rochester, N. Y.—"Arc Welding by the D.C. Process," W. P. Madden, General Electric Co.

Dec. 17, 1924, Buffalo, N. Y.—"Arc Welding by the D.C. Process," James Burke, president, Burke Electric Company.

Jan. 14, 1925, Rochester, N. Y.—"Welding and Cutting by the Oxy-Acetylene Process," S. W. Miller.

Feb. 18, 1925, Buffalo, N. Y.—"Welding and Cutting by the Oxy-Acetylene Process," Air Reduction Sales Company.

March 18, 1925, Rochester, N. Y.—"Resistance Welding and the Electrical Process," M. G. Littlefield, Thomson Electric Welding Co.

April 15, 1925, Buffalo, N. Y.—"Cutting and Welding by Carbon Arc, S. L. Walworth, Acheson Graphite Company.

May 20, 1925, Rochester, N. Y.—"Cutting and Welding by the Oxy-Acetylene Process," Air Reduction Sales Company.

Section Meetings:

A meeting of the Chicago section was held on Sept. 5. J. C. Headley, of the Linde Air Products Co., presented a paper on "Bronze Welding of Cast Iron Pipe." Motion pictures were shown illustrating the bronze welding of 6-in. cast iron pipe, made by the Long Island Lighting Co. at Bay Shore, L. I. These motion pictures were furnished through the courtesy of the Linde Air Products Co. The meeting was an exceedingly interesting one and the subject is a comparatively new one which deserves particular mention.

The New York Section is planning to open up the year's activities with a get-together meeting on Oct. 14th in the Engineering Societies Building. The section officers feel that it is essential to have a large attendance at the first meeting of the section and have accordingly arranged a feature program including refreshments, demonstrations and some very valuable papers on railroad welding, by all processes.

Membership Drive Is On!

On page 6 of this journal there is printed a message to every member of the Society from the Chairman of our Membership Committee.

You are requested to get one new member. A record will be kept of all the members who fulfill this obligation.

An extra copy of the membership directory, together with an application blank, will be furnished upon request.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

Positions Vacant

V-18. Acetylene welder wanted in Philadelphia, experienced in all metals. Full particulars first letter, hourly rate and names of employers for past three years. Electric welding knowledge helpful but not essential. Expenses refunded if competent after three months.

V-19. Electric welder wanted in Philadelphia with cast iron experience. Full particulars first letter, hourly rate and names of employers for past three years. Acetylene welding knowledge helpful but not essential. Expenses refunded if competent after three months.

Services Available

A-23. Welder desires position. Have taken the General Electric Training Course and have had five months' experience with the General Electric Co. on welding wheels, oil switch vessels, gear cases and welding tanks with semi-automatic welding machine. Have also had four years' experience with Ferrocarril Central Dominicano R. R., welding oil tanks, building up shafts for locomotives, frogs, cast iron gears, locomotive frames, etc.

A-24. Acetylene welder desires work in Philadelphia or vicinity. Have had four years' experience in welding all metals.

A-25. Electric arc welder desires position. Have taken the General Electric Training Course and have had two years' experience with the General Electric Company welding various kinds of oil switch tanks, gear cases, and structural steel work.

A-26. Welder available. Am 27 years of age and have had railroad experience for over a year in New York Central and Lackawanna Railroad with both the electric arc and acetylene welding. Have welded all kinds of metal and set up own work. Have been with shipyards and small boiler shops. Can do overhead welding with either electric arc or acetylene. Would like a position within short commuting distance of New York City.

Electric Spot Welding Aluminum or Duralumin

By J. W. Meadowcroft*

Electric spot welding has been used extensively for a number of years for uniting pieces of sheet metal by a series of separate spot welds formed in the pieces to be united by a welding current passing through the pieces. This is customarily accomplished by applying, under pressure, copper electrodes which are connected to opposite sides of a source of welding current and to the opposite faces of the pieces of steel or metal to be united. The pieces to be united furnish a greater resistance to the passage of the welding current than the copper electrodes and such resistance generates a welding heat in the pieces to be joined at the spots where the electrodes are applied under pressure. Attempts have been made to unite pieces of aluminum or aluminum alloys, of which aluminum is the major constituent, by the method just described, but it has never worked out on a commercial basis and it is generally believed that it is impossible to spot weld aluminum or duralumin under the conditions prescribed.

The writer has welded many pieces of aluminum and duralumin on standard spot welding machines without making any change whatever to transformers or mechanical parts, but this is only accomplished by interposing the superposed pieces of metal to be united between sheets of resistance material and applying welding electrodes to opposite faces of said sheets under pressure, thereby generating a welding heat at a spot or spots in the pieces to be united, due to both the heat created in the pieces by resistance to the passage of the welding current and to the heat conducted from the sheets of resistance material to the pieces to be united. The resistance material should be of greater electrical resistance than either the pieces of metal to be united, or the electrodes, with the result that the greatest heat is generated at spots in the sheets of resistance material. It is also desirable that the resistance material should have less conductivity than the pieces to be united, so as to keep the heat generated in the resistance material localized at a spot or spots which are maintained, under pressure, in tight contact with the exposed faces of the pieces to be united.

In spot welding sheet aluminum or duralumin I find that the best results are obtained by using steel as the resistance material and by interposing the superposed pieces of aluminum or duralumin between sheets of steel. I have also found that to obtain the best results, the thickness of the sheets of steel should vary with the thickness of the sheets or pieces of aluminum or duralumin which are to be welded together. For example, in welding two (2) pieces of aluminum or duralumin together, each having a thickness of .050,

*General superintendent of welding, E. G. Budd Mfg. Co.; Chairman, Philadelphia Section, A. W. S.

the thickness of the sheets of steel to be used should be .018 to .020 in. When the pieces or sheets of aluminum or duralumin are united by this spot the steel sheets do not fuse whatever and can be removed very easily after the welds have been completed.

The electrodes used are preferably copper and as the sheets of steel have greater electrical resistance and less heat conductivity than either the electrodes or the aluminum or duralumin to be united, the result is the creation of localized heat spots in the sheets of steel, the heat being generated therein due to the greater electrical resistance of the steel and being largely maintained at the spots where generated, or conducted to the adjacent spots in the pieces of aluminum or duralumin due to the fact that the aluminum or duralumin is a better conductor of heat than the steel. By means of this method we have succeeded in welding commercially a metal of aluminum or an aluminum alloy without the aid of any flux or fluxes.

Welded Piping in Buildings

BY H. E. WETZELL†

The applied science of pipe welding is comparatively old. But its field has recently been extended to the welding of piping systems in buildings. Almost simultaneously from different sections of the country have come reports of building piping installations made with the aid of the oxy-acetylene blowpipe. These indicate that rapid strides are being made with this development which is so vitally interesting to piping contractors because it affects their work, procedure and processes.

The oxy-acetylene process has been used for some years as an important and accepted means of fabricating piping in the shops of individual companies and pipe lines in the field. That it has proved successful and economical in these applications predicates its advantages to the building industry. The men who specify welding for pipe lines and plant piping are usually the owners themselves, who, being free to choose their own methods, select the oxy-acetylene welded pipe joint because of strength, durability, tightness and economy. But the men who propose oxy-acetylene welding of building piping are subject to the desires or specifications of the owner, architect or engineer of the building.

To this condition can probably be attributed the fact that the practice of welding building piping is only at this time getting into full swing. The authorities mentioned had to be convinced and they have been convinced. The passive interest heretofore shown by these authorities in the welded pipe joint was probably largely due to lack of complete information on the subject. One engineer, for instance, thought a branch was welded to a main line by cutting a hole in the main line large enough to permit entrance of the

†The Smith & Oby Co., Cleveland, Ohio.

branch, which was then welded in without knowing its amount of projection into and consequent obstruction of the main line. On the contrary, however, the branch is not inserted into the main line. The procedure in making a branch connection is to shape out the end of the branch pipe with a cutting blowpipe so that it will fit the contour of the main pipe. Then the branch is butted up to the main and the latter marked by chalking around the circumference of the branch. Next a hole is cut in the main line inside of the chalked circle but equal in diameter to the inside of the branch. Finally, both the hole in the main line and the end of

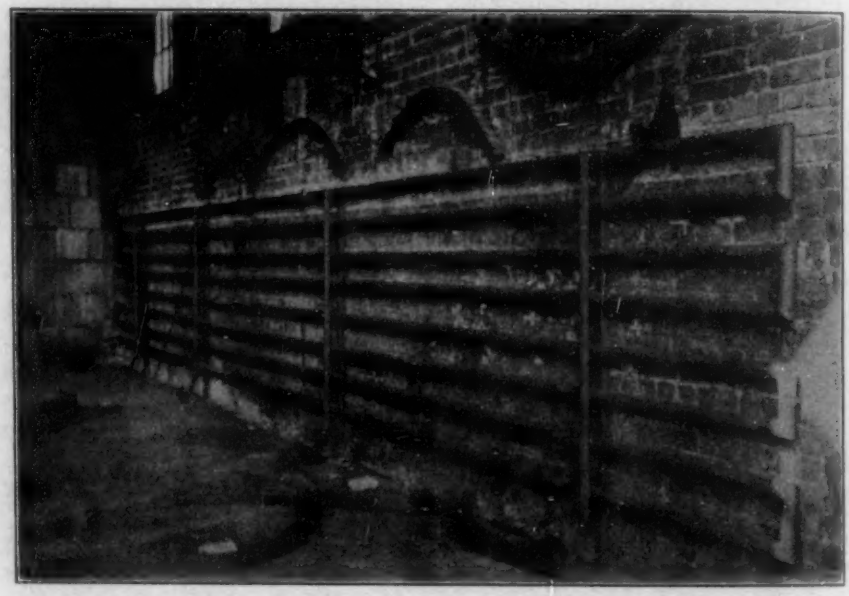


Fig. 1. Heating Coils—All Welded

the branch are beveled, fitted and welded, giving the equivalent, so far as internal pipe friction goes, of a cast fitting. And such is the case with the whole story of welded piping—a little investigation will quickly uncover its advantages.

The welded joint is stronger than any of the types of threaded joint. This is manifest when one considers that in threading a pipe its wall is appreciably cut into, thus reducing its transverse strength, in some cases as low as 50 per cent. In the case of the welded joint, however, especially where the weld is built up, the strength at least equals, and in most cases exceeds, the strength of the pipe wall itself.

Installation time and expense are saved when piping is welded. Consider the advantage of taking standard lengths of pipe to the job, then merely putting them in position, cutting and fitting them with the cutting blowpipe, then welding adjacent lengths together with the welding blowpipe. All thread cutting, leading, packing

and caulking is avoided. Also, the use of the oxy-acetylene process for this work obviates the necessity of a very detailed piping layout and the necessity of using a specifically marked length for a certain location.

The direction of run of the pipe line can be altered at will. It is merely necessary to cut butting ends to the desired angle with the cutting blowpipe, then weld them together. Special fittings are unnecessary.

In fact, no fittings are necessary other than valves and those which can be readily fabricated on the job from the pipe itself.

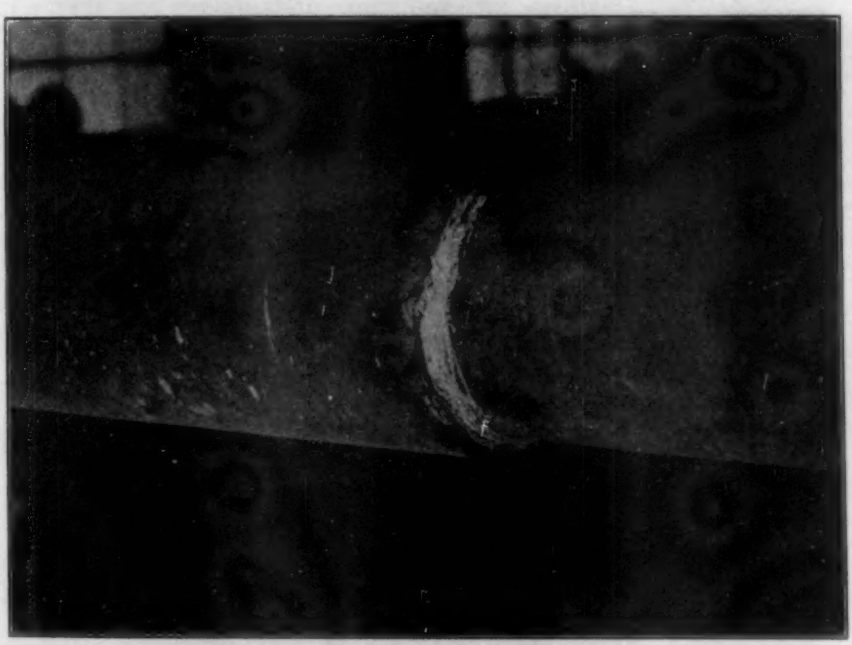


Fig. 2. Welded Reducer

This fact also has a material effect on the cost in that the expense of the cast fittings is avoided. Furthermore, since the use of fittings is avoided the weight and hence the handling time and cost of the piping is materially decreased, especially in power installations.

The corrosion which usually takes place at threaded joints and the leakage at gaskets and threads of flange connections, is avoided when pipe joints are welded. The weld, when built up, makes the joint the thickest part of the pipe line and, therefore, the part which offers most resistance to corrosion. Hence, the life of an all-welded pipe line is determined only by the life of the pipe itself.

Alteration of piping can be readily handled by means of the oxy-acetylene process. For example, take the simple case of adding a branch to a main line. Contrast this with the work required should

the job be handled with screwed connections. A whole length of pipe would have to be removed, cut and threaded, the branch connection threaded and the three resultant ends joined by a cast "T" connection. In other words, two joints to break, two cuts to make, three threads to cut and finally five joints to make. Again, summarizing the oxy-acetylene method of doing the job—two cuts to make and bevel and one joint to weld.

Another good feature of welded piping systems is their appearance. They present a smooth continuity of line unbroken by joints of fittings. And when it is necessary to cover such a line

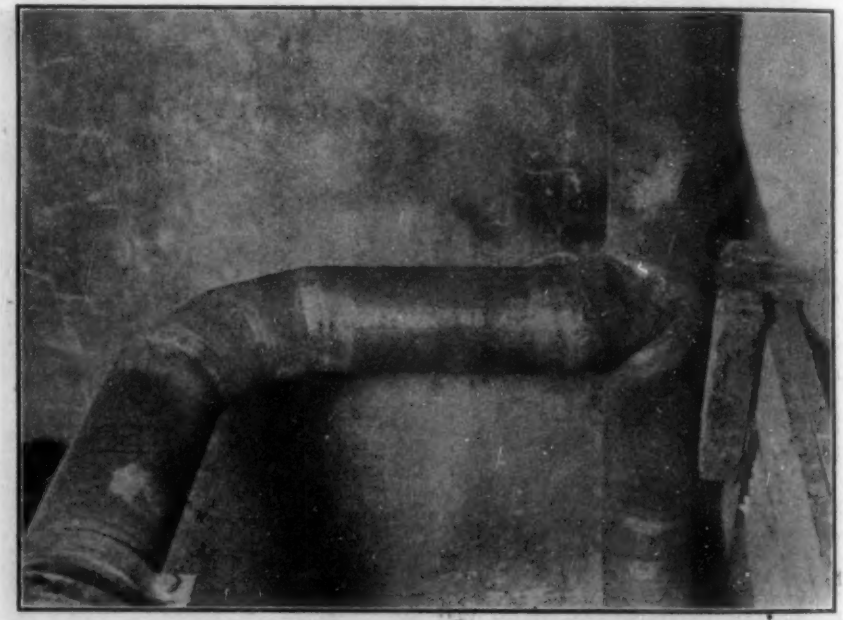


Fig. 3. Welding Makes These Bends and Connections Possible

the insulating jackets can be kept uniform. Large flange covers are obviated.

In all, the advantages of welding building piping are summed up in the following statements. Strength is increased. Close work and numerous branch connections are easily handled. The cost of thread cutting and fitting is done away with. The added weight of fittings is avoided, thus reducing handling costs. Corrosion, which usually takes place at threaded joints, is insured against as is also leakage at threads and gaskets. So it can readily be seen that the use of welded piping in buildings is both economical and practical.

Welding a Punch Press

By J. F. Irby†

Every shop in the country working with metals may not have among its equipment a punch press of such dimensions as the one illustrated here. Still there are few shop owners that are not faced, at one time or another, with the spectre of a shut-down because of damaged machinery. Thus the main point in the following incident should be interesting as typical of the wide variety of repair and reclamation work done by welding.

Welding a Punch Press

We may start with statement that when broken equipment is carefully repaired with a good reinforced fusion weld it is stronger at the repaired section than it was originally.

† Allmetals Welding & Mfg. Company, Baltimore, Md.

The figure shows a punch press frame, a gray iron casting weighing approximately two tons. A piece of metal too thick or tough broke the casting square off at the level of the table. The frame was cracked through a hollow rectangular section 19 in. wide by 20 in. deep, 6 in. thick at front, 1½ at the back and 2 in. thick at sides.

After the edges were carefully veed and the frame accurately aligned, it was preheated by gas burners and a good welding job done by competent oxy-acetylene operators. The casting was carefully covered to protect it from any draughts during welding and this covering was left in place until the casting had cooled.

After proper annealing the punch press frame was put back in service and stood up under the work for a year. Then someone again fed it too big a bite and it went. Of course, the frame was sent to the same shop which had welded it after the first accident. It was again repaired and is shown in the second illustration ready for another term of service.

The point in the story is not that one good job deserves another, or that the competent welder is an ever ready help in time of trouble, but that the second break did not run through the old weld. This was left unharmed. Nor was the new break in the region preheated for the old weld. It was in the crank bearing 4 ft. away. This, then demonstrates the original proposition, that a second break in a properly made weld need never be feared, because it holds.

Electric Arc Welding as Applied to Joints of High Pressure Steam Lines

BY A. CHURCHWARD*

In the fall of 1919 the Erie Lighting Company contracted with the American District Steam Company to install for them a 14-in. all-steel steam main extending from a new power plant which they have recently completed, some 2000 ft., to an old power plant in which they wished to dispense with the use of their old-type steam-producing equipment.

In preparing the expansion joints there were certain sleeves and other parts that the engineers thought might be welded by some process to good advantage.

The sleeves were arc-welded and machined down to actual size, after which they were tested at a hydraulic pressure of some 500 lb. and were so extremely satisfactory that it was decided to weld all the joints in the 14-in. steam main.

The work on this line was commenced in the late fall of 1919 and was not completed until about February, 1920; the welding

*Consulting engineer, Wilson Welder & Metals Co.

work, therefore, being done under the most severe winter conditions. The equipment used in welding these joints was a standard two-arc motor generator set and was located on skids and an electric line being run from one power house to the other and the machine moved from place to place as the work progressed. The welding was all done in the open, and as stated above in snowy and rainy weather and, therefore, under extremely difficult conditions.

The line was frequently tested with cold water at a hydraulic pressure of from 400 to 500 lb. per square inch, and when the steam was finally turned into this line, it was found to be absolutely tight in every joint.

The results of the welding work on this line were so extremely satisfactory that in the spring of 1920 the American District Steam Co. had a much more extensive contract with the Dayton Lighting Co., and the same company was asked to do the welding work on this line, which was constructed of 10-in., 12-in. and 14-in. pipe and was approximately one mile in length. This line carried a pressure of approximately 200 lb., but was subjected to the same hydraulic tests as indicated above on the line at Erie and with the same satisfactory results.

It should be mentioned also, some of this work must be done directly overhead and at very close quarters, although the welding was readily accomplished by the electric arc.

Welding High Speed Steel*

By S. W. Miller†

In any fusion welding process the metal must be melted and when it solidifies it reverts to the cast condition. High speed steel is an alloy containing about 0.70 per cent carbon, 7 per cent chromium, 17 per cent tungsten, 0.40 per cent manganese, about 0.25 per cent vanadium being sometimes added. It should be understood that the amounts of these element vary widely in different high speed steels, and that it is therefore not possible to produce one welding rod that will answer all cases, and also that as some of the elements are reduced in amount by the melting and as the amounts lost are indeterminate, it is probably not possible to obtain anything like the same chemical composition in the added metal as in the base metal.

High speed steel, in the cast condition, is very brittle, and a large part of it consists structurally of carbides of probably all the elements in the alloy. These carbides exist in large masses and cause brittleness.

*Data furnished in connection with the "informational service" maintained by the American Bureau of Welding.

†Union Carbide & Carbon Research Laboratories.

Before high speed steel can have any value for cutting metals these carbides must be dissolved, at least to a very large extent, in the iron, and must be held in this condition by rapid cooling. The solution of these carbides, in the case of a casting, requires a high temperature for a long time, much longer than is necessary in the case of a forging.

It might be possible in the case of a minor defect, or where the tool is not pushed to the limit, to make a weld that would answer the purpose, but there is good reason to believe that the weld would fail under severe service before the rest of the tool.

The principal difficulty, however, is that it is practically impossible to make a weld in any high speed steel that will not crack next to the weld, either while cooling off or when it is put in service. As stated before, the cast metal is brittle due to the presence of free carbides, and during the cooling down these carbides, which are themselves brittle, create zones of brittleness throughout the cast weld and in the melted zone of the base metal.

Therefore, if it is desired to try welding of high speed steel, small strips of the material should be used for welding rod; the weld should be made as quickly as possible; the piece should be preheated to a bright red and cooled slowly, after which such heat treatment should be applied as may be necessary to get the carbides into solution and hold them there.

Different results may be expected with different alloys, but I have no confidence whatever that a weld can be made in high speed steel that would be the equal of the forged material, although in some cases the result may be good enough.

Oxy-Acetylene Cutting and Welding for the Plumbing and Heating Contractor

By H. E. Wetzell†

That excellent results are attendant upon the use of the oxy-acetylene process for installing piping in buildings has been demonstrated. It is a new field for welding but the several jobs handled in this manner are giving entirely satisfactory service. Oxy-acetylene welding recommends itself to owners, engineers and architects in this field because welded piping assures durability and simplified systems. For the same reasons it recommends itself to the plumbing and heating contractors who should be especially interested because welded piping costs less and is easier to fabricate and install. Most of the work can be done on the job. Odd lengths, miscut pipe, difficult bends and special fittings, for example, present no obstacles to the contractor equipped with welding and cutting facilities. Problems that formerly meant long and expen-

†The Smith & Oby Co., Cleveland, Ohio.

sive delays are now executed on the job with consequent savings for the contractor, builder and owner. In fact, all trades installing pipe in buildings are rapidly coming to recognize the all-around desirability of adopting the oxy-acetylene process in their work.

In relation to many other fields of endeavor that of installing pipe in buildings is unique because layouts are seldom twice the same. Consequently, individual problems confront the contractor on each new job. But here is where the oxy-acetylene process is particularly advantageous. After a man has learned to use his cutting and welding blowpipes on pipe he can do almost any piping job regardless of the size, shape, position or extent, just as a good carpenter with his hammer and saw can put up almost any wood structure.

Joints, connections and special fittings on high and low pressure steam, compressed air, vacuum, cold water and brine lines are economically welded. The accompanying illustrations are photographs taken on one job which the writer has lately had opportunity to observe. They were snapped at random points about the building while it was under construction.

In determining wherein oxy-acetylene cutting and welding can be employed advantageously these factors are usually considered:

1. Strength of a welded joint in comparison with other types of joints.
2. Tightness.
3. Durability.
4. Weight of piping.
5. Comparative costs involving
   - a—original installation
   - b—time
   - c—handling
   - d—covering
   - e—upkeep.
6. Appearance,
7. Possibility of easy alteration,
8. Possibility of certain special construction.

In most cases it will be found that in each item the oxy-acetylene method has the weightiest arguments in its favor.

The actual strength of any individual welded joint can only be definitely determined, of course, by actual test. But if good welding practices are adhered to and each weld carefully made the joints can be made even stronger than the pipe itself. This has been proved repeatedly by both field and laboratory tests. And as to the strength of a welded joint in comparison with a screwed joint, welding involves the addition of metal, whereas threading involves removal. Common sense dictates the answer.

The same is true in relation to tightness. Those features which permit leaks to develop and make them possible with all other types of joints do not exist in welded construction. Once a

welded joint is properly executed the possibility of leaks is reduced to a minimum. Its permanent tightness is undoubtedly one of the outstanding advantages of welded piping in building, as the expense, inconvenience and damage caused by leaky piping in this field is on the whole greater than in other piping fields.

Modern building construction involves such a large quantity of piping that weight also has become an important factor. It is involved mostly, of course, in connection with fittings, and any cast fitting weighs greatly in excess of one fabricated by welding. The

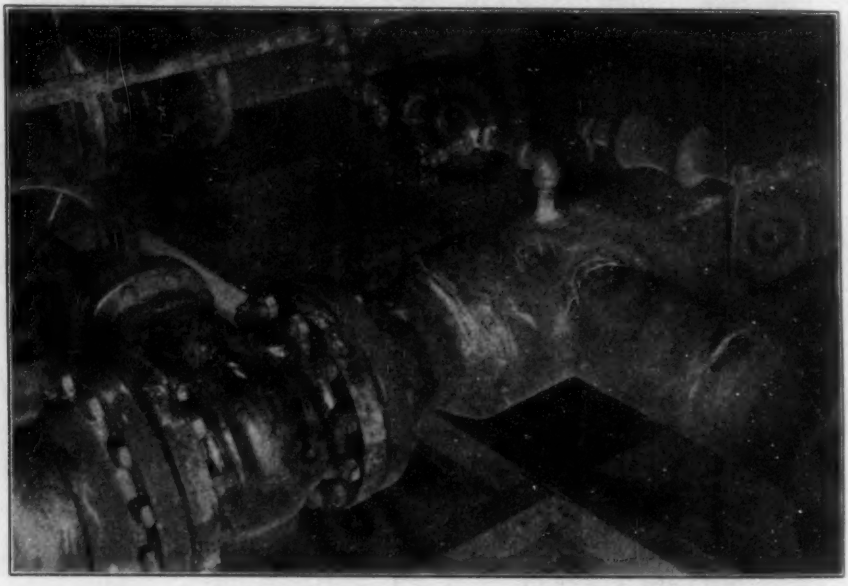


Fig. 1. Welded Connections

latter contains less metal and such parts of cast fittings as flanges and bells are eliminated.

Cost is a variable factor. Typical joints might easily entail slightly different expenditures on the same job. Yet as the results on a large number of jobs have shown, under average conditions it is easy for a contractor to determine the average or maximum costs for different types of connections and fittings, and these can be used for figuring on prospective work. Observations under all sorts of working conditions have established the cost of screwed connections and the larger the pipe size the greater is the saving over them by welding. Other factors of cost, such as the time required to complete a welded connection, the amount of handling involved, upkeep, and the cost of applying covering, are less when welded joints or fittings are compared with other types.

Take the four welded connections—Fig. 1 or even the single "T" Fig. 2. Each of these was fabricated on the job. The chance of error was eliminated and accurate fittings obtained at a very small

fraction of the cost of cast fittings which would have been required to obtain the same results.

Appearance may not always be considered of great importance, but wherever it is there can be little question but what a pipe line with a surface unbroken by unsightly fittings or bulges is the more pleasing in appearance. Especially is this true where the piping runs through a finished section of a building.

The several welded joints and connections shown in Fig. 2 are typical examples of piping fabrication which is accomplished on

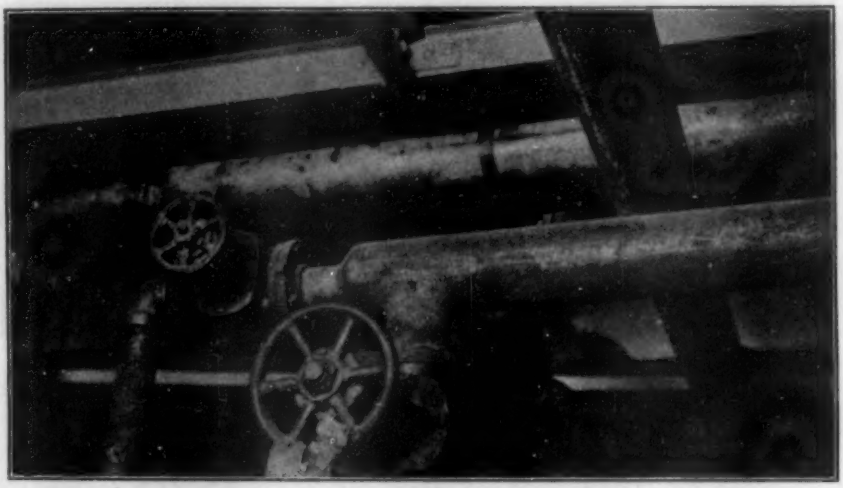


Fig. 2. Welded Joints and Connections

the job, often after the main line or fitting is in place. This is a high pressure steam line and a practical steamfitter can readily conceive how difficult it would be to obtain such a layout with standard fittings. The same result could, of course, be obtained with a special casting, but such would probably have cost more than rearranging the whole layout. Besides, to install fittings would have required more time and expense than it did to do the welding shown.

The scope of the cutting and welding process from the viewpoint of the average piping contractor is one of its most valuable assets. If an operator can reach the point on a line to do the necessary cutting and have room to execute a weld, there is hardly an emergency that can arise and not be successfully handled.

A number of instances on one installation illustrates this. For example: After putting in the main steam supply header on top of the battery of boilers, the end of one of the special bends leading from it did not center at the fitting. Instead of sending the bend back to the shop to be changed, the fitting was cut off, another opening was cut in the header, and the bend welded to it. The opening left where the fitting was cut off was closed by welding.

This quick work kept the building heated so work could continue on the inside during a cold spell. After installing one line it was desirable to connect six more laterals to it. Instead of taking the line down as would have been necessary were fittings used, the additional laterals were run up to the main line, like that shown in Fig. 3. Then an opening was cut in the line and the joint welded.

In Fig. 1 both "T" connections were installed after the large pipe was in place. The "T" connection in Fig. 2 was made under the same circumstances. Every job as large as this one involves

Fig. 3. Welding in Additional Laterals

numerous occasions where such changes in the original piping lay-out are necessary. If the contractor has to make them by the old methods—"extras" pile up. But where the changes are made the oxy-acetylene way, everyone concerned is benefited. Anticipation of what these savings amount to will often enable a contractor to submit a lower bid.

In any building, additions and changes in the various piping systems may be necessary in the future. The extent to which welded construction is employed is in no way a detriment when such changes or additions are desirable. They can be accomplished with the cutting and welding blowpipes to better advantage, at less cost, and in the majority of cases, without dismantling the piping in place. What an improvement this is in comparison with taking down a whole section of piping!

As other metal trades have acknowledged the advantage of the oxy-acetylene process and have accepted it in place of the older methods, so now the plumbing and heating contractors are adopting it for their work.

Spot Welding*

Spot welding is done on two principal types of welders.

The first type consists of welders, either hand or foot operated, in which the character and quality of the welds are dependent upon the judgment and skill of the operator.

The second type consists of welders, generally but not always power operated, in which the character and quality of the welds are independent of the judgment and skill of the operator. Such welders are generally termed automatic or semi-automatic welders. These automatic types of welders are again divided into three types.

The first type of automatic spot welder consists of machines in which the pressure is fixed by adjustment and the duration of flow of the current is controlled by a timing cam or its equivalent.

The second type of automatic spot welder consists of a machine in which the pressure is fixed by adjustment and the amount of amperage of the current is also fixed by adjustment, so that when the amperage reaches a predetermined value the circuit is broken and the welding stops.

The third type of automatic spot welder consists of a machine in which the pressure is fixed by adjustment and the current is cut off by the movement of the electrodes through a predetermined distance. This movement of the electrodes is brought about through the softening of the heated area and its yielding to the applied pressure. This method has been standard for years for automatic butt welding machines.

A large spot welder has been built for use in ship fabrication which has a 6-ft. gap and is designed with capacity to weld two ¾-in. plates. It provides a pneumatic pressure of 60,000 lb. and a current of 50,000 amp. and welds simultaneously two spots, each of some 1½-in. diameter in a few seconds. In this welder, known as the "Duplex Welder," two spots are simultaneously welded, the current crossing the plate in one direction between two electrodes and the back again between two other electrodes. Two transformers, one located on each side of the plates, are comprised in the outfit. The chief object of this duplex feature is to eliminate the large reactance drop of a conducting loop some 6 ft. in length and 1 ft. wide when traversed by some 50,000 amp. of 60-cycle current.

The character of spot welds made in practice varies all the way from a mere surface adhesion which resembles a soldered joint, to a thorough weld and full diameter of the electrode point and of such strength that when the plates are torn apart large portions of the metal of the one or the other of the plates are torn out.

The surface adhesion weld mentioned above, which is known to

*Report of the Resistance Welding Committee of the American Bureau of Welding (Welding Research Department of the American Welding Society and the Division of Engineering of the National Research Council). Prepared largely by W. Remington, Chief Engineer, Thomson Electric Welding Co.

the trade as a "stick weld," is employed very extensively in the trade for securing the edges of very thin material, about .015 in. thick, in the form of a lap seam. Welds of this character on thin material are made at the rate of 120 to 150 welds per minute on a hand-operated machine, and there is practically no indentation of the work by the electrodes.

In order to obtain a real weld on sheets .020 in. thick or thicker, the metal between the points of the electrodes must be compressed to such an extent that a depression will be made on the outside surfaces by the electrode points.

When such a depression is detrimental to the appearance of the work it can be eliminated from one of the surfaces by using against that surface an electrode having a large flat surface instead of being pointed. A pointed electrode must be used, however, against the other surface.

Spot welds are made under three distinct methods, according to the work and the machines at hand.

The first method employs comparatively light pressure at the start, so as to get considerable resistance and consequently greater heating at the adjacent surfaces of the plates, followed by heavy pressure to complete the weld after the temperature has reached the proper point.

The second method is the same as the first, except that the current is made to flow at short and frequent intervals instead of flowing constantly during the period of heating.

The third method employs heavy pressure for making the weld at the start and is continued to the finish of the weld, and the current flow is continuous. For plates of the same thickness, the third method requires a welder of much greater electrical capacity than required for either of the first or second method.

Ferrous Metals, Low Carbon, Plates Equal Thickness

Use either of the three methods—Third method preferable.

Ferrous Metals, Low Carbon, Plates Unequal Thickness

Use either of the three methods—Third method preferable.

Ferrous Metals, High Carbon, Plates Either Equal or Unequal Thickness

Any one of the above methods may be used, but the results will differ. The third method will produce perfect welds, but they will be very hard and very brittle, requiring heat treating to be of any practical value.

The second method, if property executed, will produce welds much less brittle, but will tend to cause buckling of the plates.

The spot welding of high carbon steel plates cannot be so broadly used in actual manufacturing as the spot welding of low carbon plates because of the difficulty of eliminating the brittleness of the welds. This brittleness can be very much reduced, if not entirely eliminated, by adjusting the pressure and secondary voltage so as to cause the heat to run back into the plates for area of about sixteen times the area of the actual weld. This, however, will cause

buckling of the plates if there are several welds in close proximity.

Non-Ferrous Metals

The third method produces the best results on metals of this character.

In spot welding, like butt welding, there are many special features employed to obtain welds where conditions are such that standard practice alone will not produce satisfactory results. Some of these features are as follows:

Placing a thin steel disk about the diameter of the electrode points between the plates to be welded, at the location of the desired weld.

Forming projections on one or both the plates at the location of the desired welds. These projections to come against the surface of the other plate when the plates are in position for welding.

The above features are generally resorted to when the plates are of a thickness greater than the capacity of the welder under normal methods.

Successful spot welds have been made on material ranging from 0.002 in. to 1 in. thick. When the plates reach ⅜-in. thickness the amount of power required, both electrical and mechanical, begins to increase very rapidly and especially after two or three welds have been made within 4 or 5 in. of each other. In order to get satisfactory welds on three plates, each ½ in. thick, the welds 5 in. apart, it was necessary to use 400 kw. and 7 tons' pressure.

The use of spot welding in the metal trade industries has resulted in developing many practices which are perfectly satisfactory for the particular conditions and requirements at hand; but cannot be universally used. Following are some of the practices referred to:

To obviate indentations on both plates, a large flat die is used on one side and a small steel disk under the die on the other side. This steel disk is heated to a welding temperature and is forced into the plate, so filling up what would otherwise have been an indentation.

Another method is to use two large flat dies and put a steel disk between the plates and in line with the dies.

Two or three spot welds made at one operation by using one large flat die and a special die designed so as to produce equal presure on all three spots.

Making welds at four or more points at one operation by the use of projections on one of the plates. Welds made in this manner are of variable quality and strength.

Welding a thin plate onto a thick plate by using a very pointed die against the thin plate and raising the voltage of the welding current so as to fuse the thin plate to thick plate. In this case, the thick plate does not become hot clear through, but there is a slight fusing on the surface directly opposite the pointed die. Such welds have not much strength, but are suitable for fastening a nameplate in place.

The standard spot welder is a vertical machine carrying two dies, or electrodes, one above the other, and intended to make one weld at a time; but many special welders have been built, each for welding some special job. Portable spot welders have been built weighing from a few pounds up to several tons. Large special welders, making two welds at once, have been built for structural steel work, also large welders making several welds in quick succession.

The matter of dies or electrodes for spot welding is of great importance. The ideal die should be able to withstand over twenty thousand pounds per square inch of compression stress without distorting; it should be hard enough to resist wear from contact with the work; it should be a better conductor of electricity than copper; it should be a poor conductor of heat. The ideal die has not yet been constructed; up to the present hard rolled copper dies have been the best obtainable.

Die point area, amperes used and pressure used for spot welding are not fixed quantities; but on the contrary, vary widely in the practical application of the art, especially on material up to ⅛ in. thick; the die points have a diameter equal to the total thickness of the two plates to be welded; the current used is about 50,000 amps. per square inch of die point area; the pressure used is about 20,000 lbs. per square inch of the die point area. But even these figures will vary widely according to the stiffness of the plates, the distance between the welds, and the time required for making the welds.

Appendix A*

Engineering Data Regarding Electrical Energy, Time and Mechanical Pressure Required for Various Kinds of Resistance Welding

The more the subject of Resistance Welding is studied in detail, the more apparent it becomes that no fixed values for electrical energy and pressures can be given that would apply to Resistance Welding in general.

There are so many variables entering into every weld, so many different materials to be welded, and such a wide variety of applications of the welded product, that generalities are practically useless, and each case should be treated to suit its particular requirements.

Furthermore, each individual case is practically a law unto itself unless the work is always done under the same identical conditions, which of course is impossible.

The following outline shows seven variables that enter into

*This information was furnished thru the courtesy of Mr. H. A. Woofter, Electrical Engineer of the Thomson Electric Welding Co. The American Bureau of Welding would welcome additional data from manufacturers and users. It is hoped in this way to bring about a greater extension of the use of spot welding in the assembly of parts now fabricated by riveting.

every weld, and most of these variables must be subdivided. A brief study of its ramifications demonstrates the impossibility of establishing any fixed rules to cover any great number of cases.

(1) Nature of Material to be Welded	(a) Iron	Wrought Cast
	(b) Steel	Low Carbon High Carbon Cast
	(c) Copper	Bars Rods or Tubing
	(d) Brass	Bronze Yellow and various Grades
	(e) Aluminum	Pure Duralumin
	(f) Various alloys too numerous to mention.	
(2) Kind of Weld Being Made		(a) Butt (b) Flash (c) Contact Flash (d) Spot (e) Point (f) Cross Wire (g) Seam
(3) Amount of Current or Power Available		(a) Small (b) Medium (c) Abundant
(4) Time		(a) Slow (b) Quick
(5) Power Factor of Welding Machine		(a) Low (b) Medium (c) High
(6) Pressure		(a) Light (b) Medium (c) Heavy
(7) Operator		(a) Skillful (b) Ordinary (c) Below Average

In actual practice, a butt weld of steel stock will ordinarily require about 30 kw. of power for 15 secs. and about 2½ tons pressure for 1 sq. in. of cross section.

On larger sections the power, pressure and time required per square inch increases, that is to say, these factors also are variable, and when plotted, show a rising curve.

In common practice on steel, and on small to medium sized work, pressures for butt welds vary from 2 to 5 tons, and in some special cases run as high as 8 tons per square inch. Drop forgings, and some special alloys require very high pressure to insure good welds.

Butt welds on copper, brass, aluminum, and certain other non-ferrous metals, require less pressure, but more current than for the same cross section of steel. Most of these, however, are so variable that no empirical formula can be given for them, as for instance, it takes much less current to weld round, than flat copper sections, and about 40 per cent more power to weld a given cross section of any metal in tubular form than in solid cross section.

Spot Welding Pressures, in common practice, vary from 2500 to 3000 lbs. per square inch on very thin stock, where only a "stick" weld is made, up to 15,000 lb. per square inch on low carbon plates ½-in. thick. In other cases 10,000 lb. per square inch is used on 3/16-in. low carbon steel plates.

Please note that the nature of the stock, the thickness of the stock, the proximity of the welds, the time of making welds, are all variables, not to mention the varying amounts of current that may be used, all of which affect the amount of pressure required.

Seam Welding Pressures vary as some function between the square and the cube of the thickness of the stock being welded, and also vary for different kinds of stock, for instance, steel, brass, black iron, aluminum, etc. An approximate formula has never been determined, and if ever determined, it will vary with the rate of weld.

The trend of resistance welding practice during the last two years has been such as to make obsolete practically all previously existing information. The demand has been for larger and more powerful welders to do the same work in less time. The constant cry is for more and more production, hence, practices, values, and formulae that were considered fairly standard practice two years ago are commercially impossible now, and the industry is developing so rapidly that practices which seem fairly standard and satisfactory today will be obsolete a year from now.

Table No. 1 shows meter, time and pressure readings for various sizes of stock for spot and mash welds. These readings were taken from test records and are authentic. They should be used only as a general guide, and should not be followed blindly, for a study of the values shows wide variations, even in similar work. and confirms the statement made earlier in this paper that no table of values can be given to cover any great number of cases.

Values for mash welding vary much less than for spot welding. hence the table can be followed fairly close for similar sizes of work.

Table No. 1

SPOT WELDING

	Two Sheets Total Thickness C. R. Steel	Pri. Amps.	Pri. Volts	Kva. Input	Kw. Input	Sec. V.	Time in Sec.	Diam. Die P't's.	Approx. lbs. Pressure per Sq. in.
1.	.0368 in.	21.97	235	5.16	2.45	1.55	.22	1/8 in.	7250
2.	.1296 in.	25.8	232	6.0	3.77	1.96	.25	1/8 in.	7250
3.	.1776 in.	31.0	232	7.2	4.3	2.25	.28	1/8 in.	7250
4.	.2226 in.	52.0	229	11.9	7.9	2.69	.35	1/8 in.	7250
5.	.344 in.	55.7	222	12.4	8.9	2.69	.42	1/8 in.	7250
6.	H. R. Steel .218 in.	100.0	200	20.0	17.0	2.57	.25	1/4 in.	5500
7.	C. R. 0.25 in.	100.0	416	41.6	30.0	3.75	.40	3/8 in.	6800
8.	.375 in.	220.0	368	81.0	60.0	5.95	.40	3/8 in.	6800
9.	.50 in.	325.0	392	98.0	60.0	5.95	.60	3/8 in.	4650
10.	.625 in.	390.0	368	143.0	88.0	8.2	1.0	1/2 in.	7300
	Mash Welding (Two Round Pieces at Right Angles)								
11.	2 steel rods each .225 in. dia.	17	232	3.95	3.7	1.7	1.5	Flat	5000
12.	2 steel rods each 7/16 in. dia.	70	424	29.8	24	3.1	1.4	Flat	6000
13.	2 steel rods each 1/2 in. dia.	95	410	39	28	3.4	.8	Flat	6000
14.	4 cross welds at once of 1/4 in. dia. stock	30	432	13	12	1.9	3.75	Flat	6000
15.	4 cross welds at once of 1/4 in. dia. stock	40	432	17.3	16	2.2	2.4	Flat	6000

No attempt is made here to formulate any table of values for spot welding brass. The metal itself varies so widely in its composition that it is impossible to procure two different lots of stock alike. While the most usual formulae for brass is one-third zinc and two-thirds copper, we are continually getting samples from customers that show by actual analysis all the way from 40 per cent to 80 per cent of copper. Now, bearing in mind the fact that welding setups vary for each variation of stock, it is readily apparent that there can be no fixed formulae, or table of values for spot welding brass. Instead, it is only necessary to have a few samples of the stock as it will be run in production for the particular job at hand, and determine by experimenting the best type of welder, and the best possible setup.

It is also best to determine the correct values for spot welding aluminum by experiment. The metal varies widely in hardness all the way from pure, soft aluminum to duralumin, but is so similar in appearance that there is a large chance for error unless some of the stock is actually welded to determine its composition. In all spot welding, the proximity of the spots causes a large variation in the time, and the amount of current required. This is due to the shunting or leaking of current through the spots already made. Spots should be an inch apart, if possible, for medium sized spots, and with very large spots, a still greater distance is desirable.

Table No. 2 shows how widely the values may vary for practically equal sizes of work. It demonstrates the specific nature of the art of Resistance Welding, and shows the necessity of technical knowledge to apply the proper values to any given size of work, to be done in a given time.

Table No. 2

TABLE OF VALUES ACTUALLY USED IN BUTT WELDING VARIOUS SIZES OF STEEL AND COPPER

	Dia. and Kind of Stock	Pri. Amps.	Pri. Volts	Kva. Input	Kw. Input	Sec. Volts.	Time in Sec.	Kind of Press.	Approx. Lbs. Pres. per Sq. In.	Kind of Weld
1.	.036 in. steel wire	1.0	110	.11	.10	.9	.6	Spring	....	Butt
2.	.062 in. steel wire	3.0	110	.33	.24	1.0	3.2	Spring	....	Butt
3.	.071 in. steel wire	2.5	108	.27	.20	1.25	1.5	Spring	....	Butt
4.	.106 in. steel wire	5.7	109	.62	.50	1.06	1.4	Spring	....	Butt
5.	.125 in. steel wire	6.0	112	.672	.60	1.2	1.8	Spring	....	Butt
6.	.172 in. steel rods	16.0	112	1.8	1.6	1.46	1.8	Spring	....	Butt
7.	.225 in. steel rods	40.0	112	4.48	4.0	1.82	1.4	Spring	....	Butt
8.	.3125 in. steel rods	115.0	110	12.64	11.0	2.81	1.5	Spring	....	Butt
9.	.375 in. steel rods	54	216	11.7	9.2	2.76	1.6	Spring	....	Butt
10.	½ in. dia. steel rods	68	220	15.0	13.6	2.8	5.0	Spring	....	Butt
11.	⅝ in. dia. steel rods	104	216	22.5	16.0	2.4	8.5	Toggle	3500	Butt
12.	¾ in. dia. steel rods	155	212	33.0	21.0	2.95	8.5	Toggle	4000	Butt
13.	1 in dia. steel rods	200	210	42.0	26.0	3.45	13.4	Toggle	4000	Butt
14.	2 in. x ½ in. steel bars	170	204	34.7	29.0	3.5	15.4	Toggle	5000	Butt
15.	1¾ in. x ¾ in. steel bars	250	198	49.5	31.0	3.25	15.6	Toggle	6000	Butt
16.	2 in. x ¾ in. steel bars	240	196	47.0	32.0	3.45	23.0	Toggle	6000	Butt
17.	¾ in. dia. copper rods	400	200	80.0	50.0	4.06	2.0	Toggle	6000	Butt
18.	⅝ in. dia. copper rods	1200	160	192.0	92.0	8.5	1.2	Spring	2480	Butt
19.	⅜ in. dia. copper hoop 6 in. dia.	450	272	122.0	80.0	8.0	0.7	Spring	5800	Butt
20.	¼ in. dia. copper rods	90	218	19.6	17.0	1.68	1.2	Weights	4840	Butt
21.	⅜ in. dia. copper rods	137	216	29.7	20.0	2.2	2.8	Weights	2780	Butt
22.	½ in. dia. copper rods	155	212	33.0	22.0	2.38	9.0	Weights	2080	Butt
23.	2½ in x ⅝ in. steel bars	200	324	65.0	49.5	3.45	13.0	Toggle	7500	Butt
24.	2¾ in. x 1 in. steel bars	250	327	82.0	54.0	3.95	49.0	Toggle	9800	Butt
25.	2 in. dia. steel rods	220	510	112.0	70.0	3.95	16.0	Toggle	14000	Butt

Table No. 2 shows a list of values actually used in butt welding various sizes of steel and copper rods and bars. Reference to two cases will illustrate the astonishing differences caused by a variation in the physical form of the work. Item No. 19 of Table No. 2 shows a ⅜-in. diameter copper rod as taking 122 k.v.a. of power to weld, while Item No. 21 shows a similar sized rod taking only 29.7 k.v.a. This variation is due to the fact that Item No. 19 was in the form of a 6-in. diameter ring with a consequent leakage around the ring in parallel with the weld, while Item No. 21 was two separate pieces of stock. It required a special welder, throughout, to handle Item No. 19. It could also be shown that it takes less power to weld round copper stock, than flat stock of equal cross section. Also that it takes from 40 per cent to 60 per cent more power to weld equal cross sections when in the form of pipe

or tubing, than if it were solid. This phenomenon is due, in part, to the great increase in radiating surface of the tubular form, and there are also electrical reasons, too technical to be entered into here.

Flash welding will generally require only 50 per cent or 60 per cent as much power as butt welding for a given cross section. The Flash Weld is stronger, and usually more quickly made. Also there are many alloys that can be welded *only* by the flash method. It is evident, therefore, that from the standpoints of economy, production and reliability, the flash welding process should be used. No table of Flash Welding Values is attempted here. Due to the nature of the process, which electrically is somewhat similar to an arcing ground, the instrument readings are so erratic that a table of values is useless.

There are but two metals, so far as is known, that cannot be welded by one or more methods of resistance welding. They are tin and lead. Therefore, it is only necessary to get reliable information regarding any welding proposition, excepting tin and lead, to insure successful welding.

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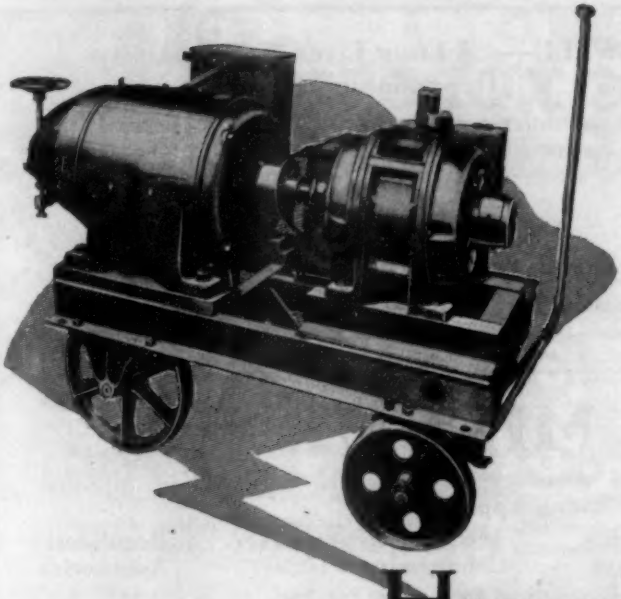

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